#39139154 ID:88066000 TA 418.74 .C37 1986

MATCHING MONUMENTS TO SOIL TYPES

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February 1986

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INTRODUCTION

This study was conducted to evaluate the present survey monument materials in regards to corrosion resistance characteristics. Cadastral Survey is constantly evaluating new and improved materials to ensure that cadastral monuments are as durable as possible.

This report discusses the various types of materials presently being used by the Bureau of Land Management and presents the advantages and disadvantages of each.

Soil conditions are also discussed and a general guide is provided for matching the proper monument materials to various soil and vegetation conditions.

MATCHING MONUMENTS TO SOIL TYPES

There are many factors that govern the corrosivity of a given soil. Some of these factors are as follows:

1. pH (logarithm of the reciprocal of hydrogen ion concentration).
2. Electrical conductivity
3. Porosity (permeability)
4. Dissolved salts
5. Organic matter
6. Presence and hardness of water.
7. Temperature.

Of these factors the pH, conductivity, and temperature are the easiest to measure and are important parameters. The pH of a solution denotes its acidity or alkalinity. The neutral pH value is 7 with drinking water ranging from pH 6.5 to 8.5. Acids have values lower than 7 and the lower the pH number, the stronger the acid. Alkaline (basic) values are higher than pH-7 and the higher the number, the stronger the base.

Generally, low pH values indicate a more rapid rate of corrosion than do high pH values. Steel and cast iron are rapidly corroded by low pH waters. Galvanized steel is corroded by low pH fluids, but at a lower rate.

pH TABLE

RELATIONSHIP OF pH AND HYDROGEN ION CONCENTRATION

	pH	Hydrogen concentration, gram mols per liter		
	0	1.0	10^{0}	Strong Acid
	1	0.1	10^{-1}	
	2	0.01	10^{-2}	
Acid range	3	0.001	10^{-3}	
	4	0.000,1	10^{-4}	
	5	0.000,01	10^{-5}	
	6	0.000,001	10^{-6}	Weak Acid
Neutral	7	0.000,000,1	10^{-7}	
	8	0.000,000,01	10^{-8}	Weak Base
	9	0.000,000,001	10^{-9}	
Alkaline	10	0.000,000,000,1	10^{-10}	
Range	11	0.000,000,000,01	10^{-11}	
	12	0.000,000,000,001	10^{-12}	
	13	0.000,000,000,000,1	10^{-13}	
	14	0.000,000,000,000,01	10^{-14}	Strong Base

The symbol p comes from the German word "Potenz" (meaning power).

The symbol H refers to the Hydrogen Ion concentration.

ALUMINUM

Aluminum has been chosen for monument material in some environments for the following reasons:

1. Good corrosion resistant qualities.
2. Low density (lightweight).
3. Relatively high strength.
4. Low cost.

Aluminum resists weathering and corrosion by forming a protective superficial film of oxide (Al_2O_3). This film forms and prevents corrosion from penetrating deeper into the metal. A thin film, almost invisible, is adequate to prevent further oxidation under most normal conditions. However, in the presence of chlorine, alkalies, certain acids and salt water, the film may be broken down and corrosion may result.

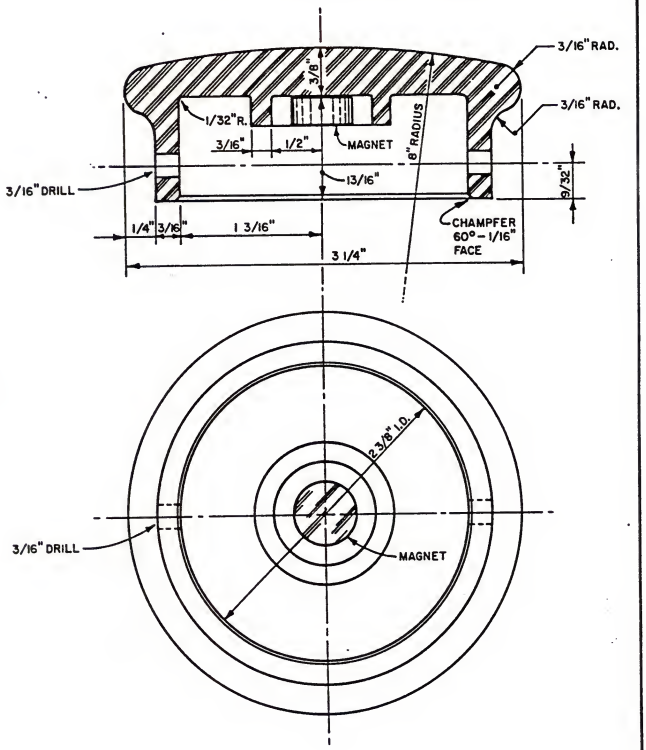
Most aluminum alloys that are heat treated are less resistant to corrosion than is pure aluminum or aluminum-manganese alloys. There are a few exceptions to this rule such as Aluminum Alloy 6053, which has increased corrosion resistant qualities in the quenched state.

There are some disadvantages to the use of aluminum and they are listed below:

1. The aluminum will not last well in salt environments or some acid soils.
2. Aluminum has a low melting point (approximately 1150°).
3. The aluminum should not be used in any soils containing copper.
4. When used in the rod form, monuments may bend easily.

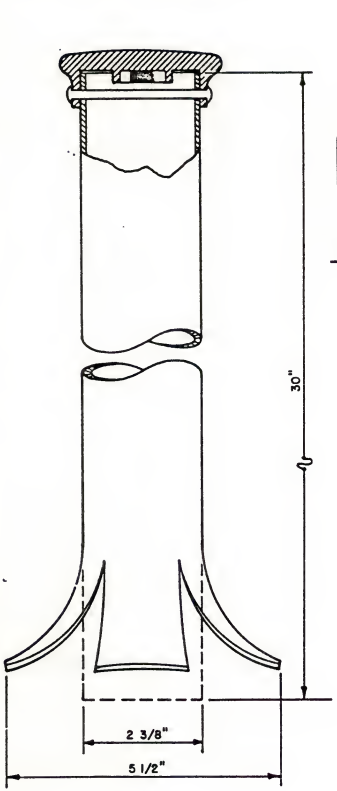
The corrosion resistance properties of aluminum alloys may be improved by providing an anodizing treatment. This process produces a tough adherent coating of aluminum oxide at the surface of the material. Anodized aluminum monuments are presently being evaluated in the BLM alkaline test bed near Salt Lake City, Utah.

Specification No. 9691.43

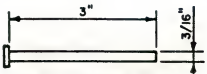


Drawing No. 2

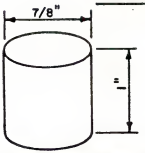
Specification No. 9691.43



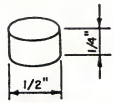
PIPE MONUMENT



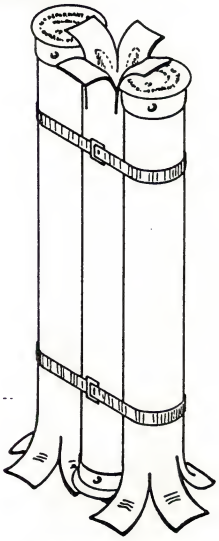
SOLID ALUMINUM RIVET



SUB-SURFACE MAGNET



CAP MAGNET

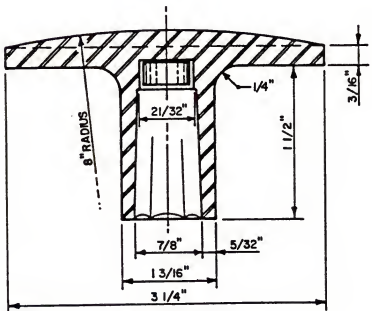


BUNDLING FOR SHIPMENT

Drawing No. 3

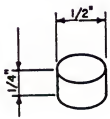
REGULATION ALUMINUM DRIVEN-TYPE ROTATING 3/4" ROD MONUMENT

Specification No. 9691.42



CROSS SECTION

LOGO CAP



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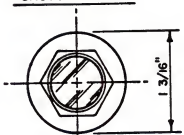
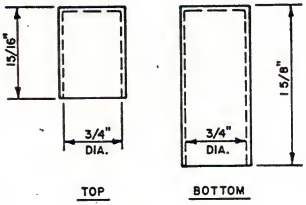


BOTTOM VIEW

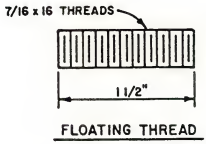
Drawing No. 2

REGULATION ALUMINUM DRIVEN-TYPE ROTATING 3/4" ROD MONUMENT

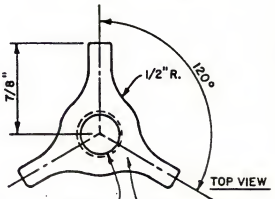
Specification No. 9691.42

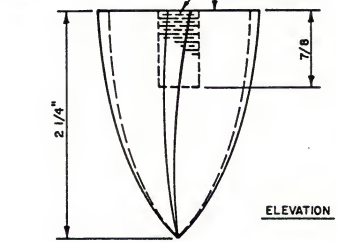


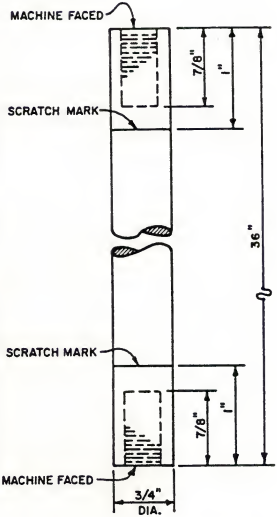
PLASTIC CAP



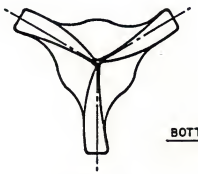
FLOATING THREAD







SECTIONAL ROD



POINT

Drawing No. 3

REGULATION GALVANIZED STEEL

The galvanized steel (regulation pipe) monument has been used by BLM for many years and continues to be a good monument. The following statement was given on Page 247 of BLMs "Manual of Surveying Instructions" dated 1947.

> "The Bureau of Land Management has adopted a standard iron post for monumenting the public-land surveys, which will be generally used unless exceptional circumstances warrant the use of other material. This practice is deemed so important that no substitutions are permitted excepting as provided in Section 239, and if authorized, a statement will be given in the field notes."

The regulation galvanized steel monument was chosen to be BLMs standard for the following reasons:

1. High strength.
2. Good corrosion resistant qualities.
3. Years of experience with varying types of monument materials.
4. Reasonable cost.

The regulation standard pipe body, ASTM A-53 was found to resist corrosion better when galvanized by dipping the pipe into a hot zinc solution.

Although this monument continues to be a good product, there are some disadvantages to its use. The disadvantages are:

1. The monument does not protect over a large pH range. Both acid and alkaline soils corrode the monument.

2. The monument is not resistant to salt environments.

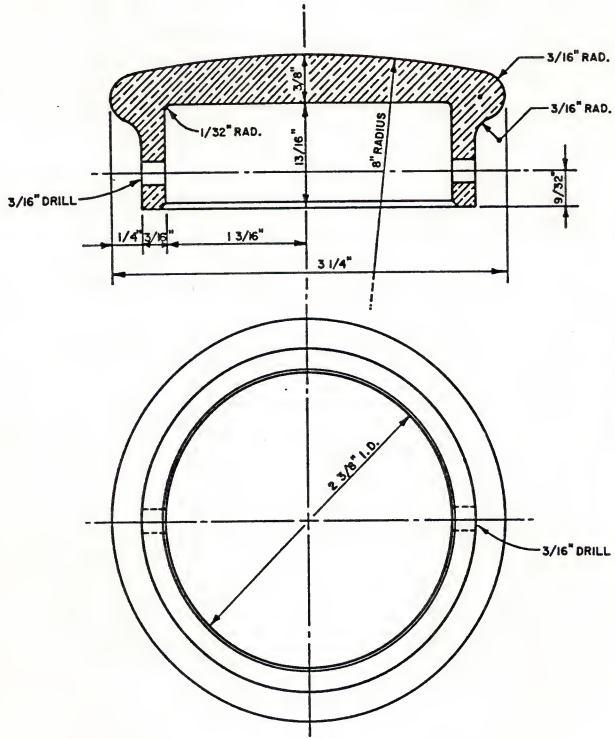
3. If the galvanizing coating is penetrated, the oxidation rate accelerates.

In a report (No. 76-5) published by Mr. Kenneth Jacobs, Department of Transportation, Augusta, Maine in 1976, interesting information was revealed relating to highway culvert life.

> "Aluminum culverts are resisting corrosion better than zinc coated steel culverts for those installations where the pH is between 5.8 and 7.9 with resistivity readings above 8250 ohm cm."

REGULATION IRON (STEEL) PIPE MONUMENT

Specification No. 9691.41

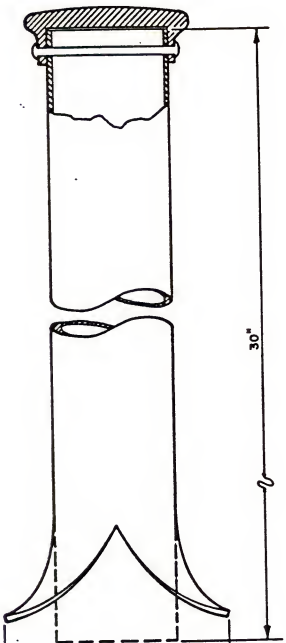


BOTTOM VIEW

Drawing No. 2

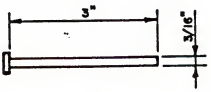
REGULATION IRON (STEEL) PIPE MONUMENT

Specification No. 9691.41

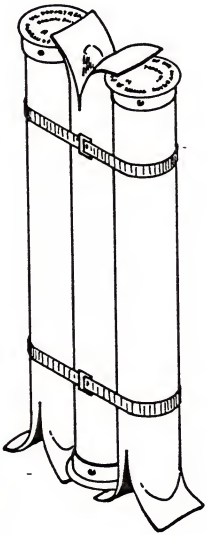


PIPE MONUMENT

SUB-SURFACE MAGNET



STAINLESS STEEL RIVET



BUNDLING FOR SHIPMENT

Drawing No. 3

STAINLESS STEEL:

There are many types of stainless steel; however, for survey applications and for economic reasons, only two types (Type 316 and Type 304) are recommended for use.

Stainless steel has been chosen for a monument material for the following reasons:

1. Excellent corrosion resistant qualities.
2. High strength.
3. Resistant to many acids including hot and cold nitric acid.
4. Provides corrosion protection over a wide pH range.

Stainless steels have the ability to form an oxide film, usually invisible, which acts as a constant protection against further corrosion on the underlying metal. In contrast to films on ordinary steels, the film is very stable, extremely tough and continuous, and is very adherent. If the film, chiefly composed of chromium oxide is broken by scratching or chemical action, it reforms quickly and continues to protect.

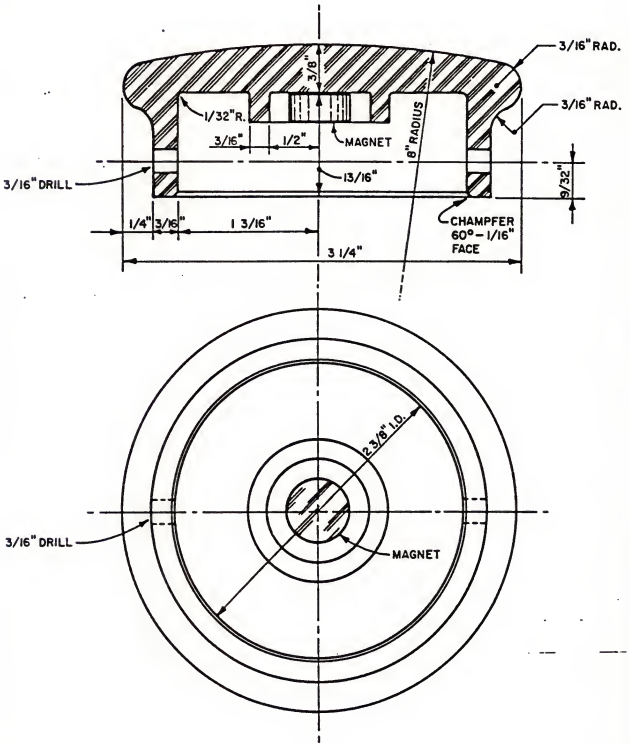
Stainless steel Type 316 and Type 304, have excellent toughness at temperatures as low as liquid helium (-45°F) and are useful for severe stress applications at elevated temperatures.

There are some disadvantages to stainless steel:

1. More expensive than other monuments.
2. High density (heavier than aluminum monuments).

REGULATION STAINLESS STEEL PIPE MONUMENT

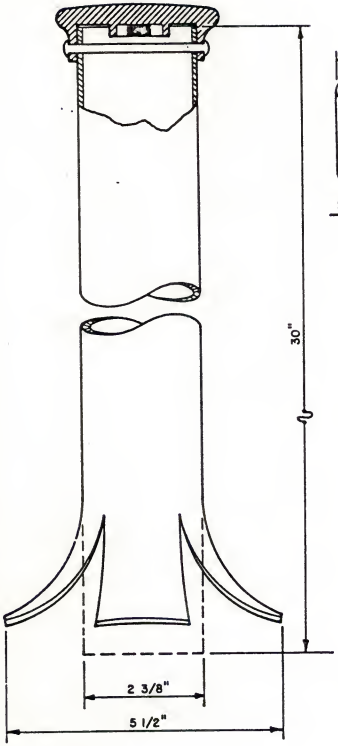
Specification No. 9691.47



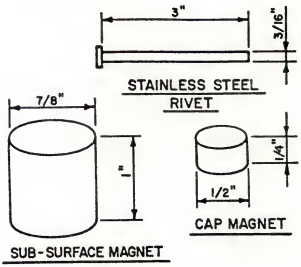
Drawing No. 2

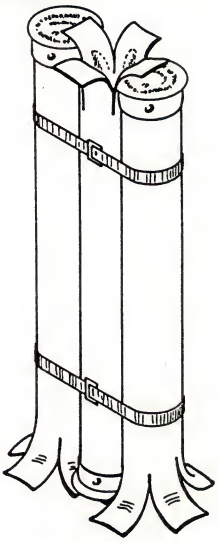
REGULATION STAINLESS STEEL PIPE MONUMENT

Specification No. 9691.47



PIPE MONUMENT



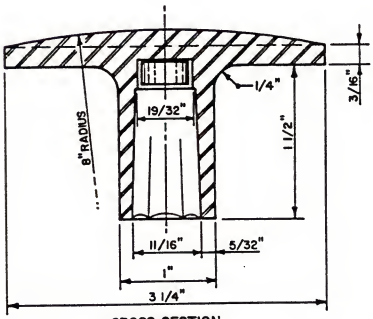


BUNDLING FOR SHIPMENT

Drawing No.3

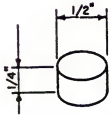
REGULATION STAINLESS STEEL DRIVEN-TYPE ROTATING ROD MONUMENT

Specification No. 9691.45

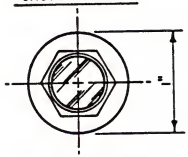


CROSS SECTION

LOGO CAP



CAP MAGNET

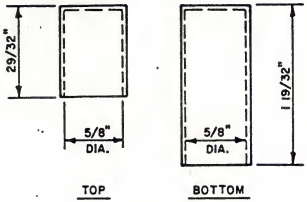


BOTTOM VIEW

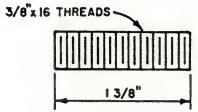
Drawing No. 2

REGULATION STAINLESS STEEL DRIVEN-TYPE ROTATING ROD MONUMENT

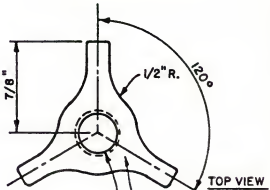
Specification No. 9691.45

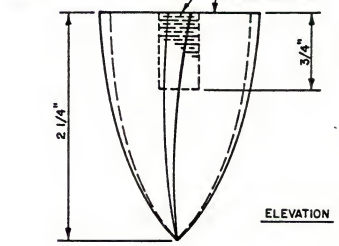


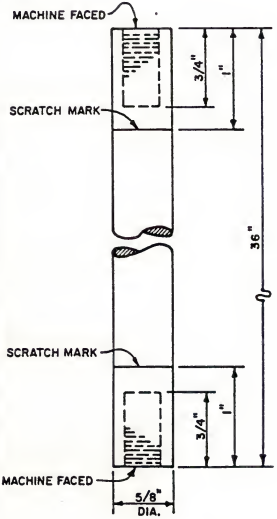
PLASTIC CAP



FLOATING THREAD







SECTIONAL ROD

POINT

Drawing No. 3

FIBERGLASS:

There may be areas where fiberglass monuments may be used. Some advantages for the use of fiberglass are as follows:

1. Excellent corrosion resistant qualities.
2. Light in weight.
3. Low cost.

Fiberglass would be chosen over PVC (Polyvinyl Chlorine). material for two reasons:

1. BLM has conducted a 15 year endurance test on fiberglass monuments and only has a 3-year endurance test on the PVC material.

2. If burned, the fiberglass monument will leave glass fibers for location identification.

Although the fiberglass monument has excellent corrosion resistant characteristics there are some drawbacks:

1. Low melting point.
2. Unknown ultraviolet affect over very long exposure to the sun.

The fiberglass monument should never be used in timbered areas or brush areas where a fire could destroy the monuments. This monument should be limited to areas having minimum or no vegetation.

RECOMMENDED MONUMENT TYPES FOR VARYING SOIL CONDITIONS

1. Strong Acid Soils

   pH - 6 and below

   A. First Choice - Stainless Steel Type 316 or 304.
   B. Second Choice - Aluminum.
   C. Third Choice - Standard Galvanized Steel.

2. Strong Alkaline Soils

   pH - 8 and above

   A. First Choice - Stainless Steel Type 316 or 304.
   B. Second Choice - Aluminum.
   C. Third Choice - Standard Galvanized Steel.

3. Normal Soils

   pH - 6-8

   A. First Choice - Stainless Steel Type 316 or 304.
   B. Second Choice - Aluminum.
   C. Third Choice - Standard Galvanized Steel.

4. Soil Containing Salts

   A. First Choice - Stainless Steel Type 316 or 304.
   B. Second Choice - Aluminum.
   C. Third Choice - Standard Galvanized Steel.

5. Wooded or Timbered Areas

   A. First Choice - Stainless Steel.
   B. Second Choice - Standard Galvanized Steel.

   Note: Aluminum monuments are not recommended due to low melting point temperature.

6. Heavy Brush and Grassland Areas

   A. First Choice - Stainless Steel.
   B. Second Choice - Standard Galvanized Steel.

   Note: Aluminum monuments are not recommended due to low melting point temperature.

7. Minimum or No Vegetation

   A. First Choice - Stainless Steel.
   B. Second Choice - Fiberglass.
   C. Third Choice - Aluminum.
   D. Fourth Choice - Standard Galvanized Steel.

EXAMPLES OF FIRE DAMAGE

TO

VARIOUS TYPES OF MONUMENTS

BURN SITE NUMBER 2

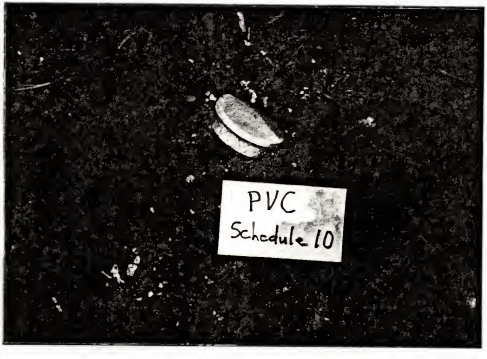
Location: Shasta Trinity National Forest
NE Quarter of Section 14, Township 37N
Range 1E, Mt. Diablo, Meridian, California

Fuel Type: Mixed conifer Logging Slash

Inspection Date: June 16, 1983

Polyvinyl Chloride, PVC, Yellow (SE), Schedule 10

Burn Site No. 2
Set June 9, 1982
Inspection Date - June 16, 1983

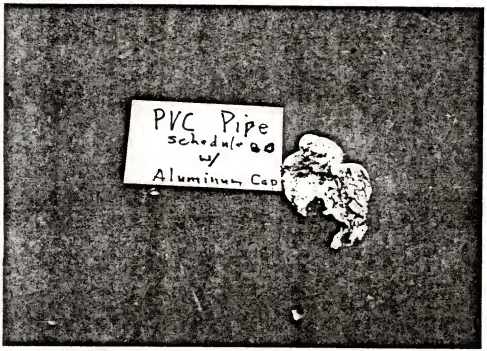


There was no evidence of this pipe above ground level. The pipe had melted in the heat and there was no evidence of the material above ground level. Below ground level the pipe was found to be in excellent condition.

The cast aluminum-magnesium alloy cap had an irregular surface with ripples indicating that a near melt condition had been reached in the heat.

Polyvinyl Chloride, PVC, White (SE), Schedule 80

Burn Site No. 2
Set June 9, 1982
Inspection Date - June 16, 1983



There was no evidence of this pipe above ground level. The pipe had melted in the heat and there was no evidence of the material above ground level. Below ground level the pipe was found to be in excellent condition.

The cast aluminum-magnesium alloy cap has completely melted.

Galvanized Iron Post (Standard Monument)

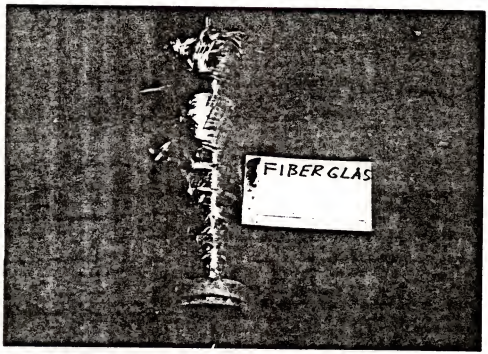
Burn Site No. 2
Set June 9, 1982
Inspection Date - June 16, 1983

This monument came through the fire in very good condition. The pipe was not damaged and the galvanizing appeared to be in very good condition.

The brass cap was not damaged by the fire. The cap was in excellent condition.

Fiberglass, Schedule 10

Burn Site No. 2
Set June 9, 1982
Inspection Date - June 16, 1983



This monument was severely damaged in the fire. All resin had melted away and the monument had broken at ground level. Only frayed glass fibers remained of the pipe body above ground. Below ground level the pipe was in very good condition.

The cast aluminum-magnesium alloy cap showed evidence of melting on the outer edges. The top of the cap had a checked pattern indicating that the metal had been very near a liquid state.

Anodized Aluminum Post

Burn Site No. 2
Set June 9, 1982
Inspection Date - June 16, 1983

Both the pipe body and cap of this m monument came through the fire in very good condition. It should be noted that this cap was a forged aluminum cap.

Aluminum Rod, 3/4", 6063-T6

Burn Site No. 2
Set June 9, 1982
Inspection Date - June 16, 1983

The rod section of this monument had cracks and raised portions, indicating a near liquid state. At about 18 inches above ground level the rod had broken and the top portion of the rod and cap had fallen to the ground. The forged aluminum cap was in good condition.

Carsonite Rod, 5/8"

Burn Site No. 2
Set June 9, 1982
Inspection Date - June 16, 19863

This monument was severely damaged in the fire. All resin had melted away and the rod had broken at ground level. Only frayed glass fiber remained above ground level. Below ground level, the rod was in very good condition.

The cast aluminum-magnesium alloy cap had melted. The cap magnet could be seen and was in very good condition.

Stainless Steel Rod, 5/8", Type 304

Burn Site No. 2
Set June 9, 1982
Inspection Date - June 16, 1983

The stainless steel monument was not damaged by the fire. This rod was found to be in very good condition.

A cap had not been placed on this monument when it was set on June 9, 1982.

COMMENTS CONCERNING THE BURN

According to Mr. Bill Rametes, National Forest Service, Redding District, this prescribed burn was a normal type slash fire. The fuel in this burn area was a mixed conifer logging slash with very little grass or brush. Although temperature measurements were not taken, the fire most likely did not have a uniform temperature. It is believed that some areas of the fire burned at a higher temperature than other areas. So conclusions drawn from this inspection should be tempered with the above knowledge. It should be pointed out, however, that all monuments were set relatively close to each other in one area (approximately 20' x 10'), and the fuel loading in this area was fairly uniform.

The fact is that some aluminum monuments melted while others did not. Forest Service representatives felt that hot spots in the fire may account for this condition. Another fact is that both aluminum pipes survived the fire while the aluminum rod did not. Examining this condition more closely, the pipes have a much larger surface area than the rod has. Since aluminum is an excellent conductor, it could have conducted some of the heat from the hot side of the pipe, leading edge of the fire, to the cooled side, and also conducted heat to the ground and kept the temperature from rising above the melting point for aluminum, approximately 1080° F. The surface area in contact with the ground is much larger for the pipes also.

Another observation made from this inspection was that the cast aluminum-magnesium alloy caps melted more readily than the pure aluminum caps. This could be accounted for by having different temperatures within the fire.

The carsonite, fiberglass, and PVC monuments were either severely damaged or destroyed and are not recommended for use in this type of environment.

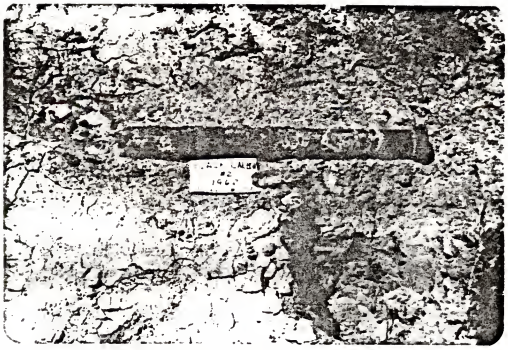
The standard iron post type monument and the stainless steel rod were <u>not</u> damaged by the fire.

EXAMPLES OF CORROSION DAMAGE

TO

VARIOUS TYPES OF MONUMENTS

Standard Black Carbon
(20 Years Duration)



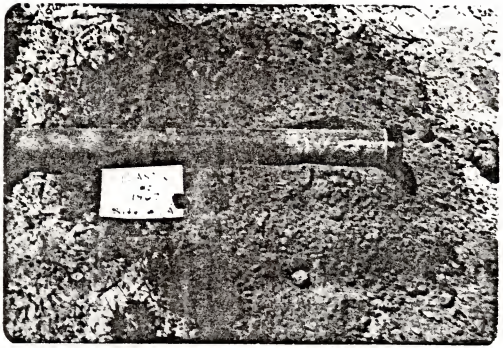
This monument was set in alkaline soil (pH-8) in 1962.
Inspection Date - June 23, 1982

* * *

Galvanized Wrought Iron
(20 Years Duration)

This monument was set in alkaline soil (pH-8)
Inspection Date - June 23, 1982

Fiberglass Monument
(15 Years Duration)



This monument was used in alkaline soil (pH-8) in 1967
Inspection Date - June 23, 1982

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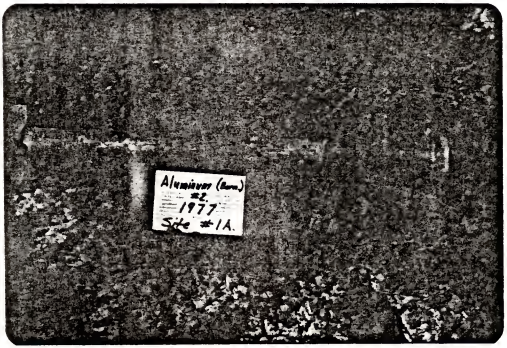
Aluminum Pipe
(5 Years Duration)



This monument was set in alkaline soil (pH-8) in 1977
Inspection Date - June 23, 1982

Aluminum Rod
(4 Years Duration)

This monument was set in alkaline soil (pH-8) in 1978
Inspection Date - June 23, 1982

* * *

Stainless Steel Type 316
(4 Years Duration)

This monument was set in alkaline soil (pH-8) in 1978
Inspection Date - June 23, 2982